

DEPARTMENT OF AGRICULTURE,
CEYLON.

BULLETIN No. 69.

NOTES ON THE HABITS AND LIFE-
HISTORY OF THE INDIAN
GLOW-WORM

(An Enemy of the African or Kalutara Snail)

BY

J. C. HUTSON, B.A., Ph.D.,
Entomologist.

AND

G. DOUGLAS AUSTIN,
Assistant in Entomology.

Peradeniya,
May, 1924.

COLOMBO :
A. C. RICHARDS, ACTING GOVERNMENT PRINTER, CEYLON.

1924.

DEPARTMENT OF AGRICULTURE.

Administrative :-

The Hon. Mr. F. A. STOCKDALE, M.A., F.L.S. Director of Agriculture.
 A. W. R. JOACHIM, B.Sc., A.I.C., Dip. Agr. (Cantab.) Office Assistant.
 J. N. CULANTHAVALU Chief Clerk.

Research—Laboratories :-

T. PETCH, B.A., B.Sc. Botanist and Mycologist.
 J. C. HUTSON, B.A., Ph.D. Entomologist (on leave).
 R. O. ILIFFE, M.A., Dip. Agr. (Cantab.) Economic Botanist.
 M. K. BAMBER, M.R.A.C., F.I.C., F.C.S. Agricultural Chemist.
 C. H. GADD, B.Sc. Assistant Mycologist (on leave).
 M. PARK, A.R.C.S. Assistant Mycologist.
 F. P. JEPSON, M.A., F.E.S., M.S.E.A.C. Assistant Entomologist.

Research—Plant Pest and Disease Inspectorate :-

N. K. JARDINE, F.E.S. Inspector for Plant Pests and Diseases, Central.
 A. T. REEVE, A.R.C.S. Inspector for Plant Pests and Diseases, Southern.

Research—Experiment Stations:-

T. H. HOLLAND, M.S.E.A.C. Manager, Experiment Station, Peradeniya.
 V. CANAGARATNAM, Dip. Agr. (Poona). Manager, Experiment Station, Anuradhapura (acting).

Agricultural Branch :-

G. G. AUCHINLECK, M.Sc., F.I.C., F.C.S. Divisional Agricultural Officer, Central.
 G. HARBOUR, M.S.E.A.C. Divisional Agricultural Officer, Northern.
 F. BURNETT, B.A.C. Divisional Agricultural Officer, Southern.
 G. E. J. HULGALLE, Dip. Agr. (Cantab.) Divisional Agricultural Officer, North-Western.

Gardens Branch :-

H. F. MACMILLAN, F.R.H.S., F.L.S. Superintendent of Botanic Gardens.
 T. H. PARSONS Curator, Royal Botanic Gardens, Peradeniya.
 J. J. NOCK Curator, Hakgala Gardens.

BOARD OF AGRICULTURE.

Ex officio Members.

His Excellency the Governor, President.	The Director of Agriculture.
The Hon. the Colonial Secretary, Vice-Pres., m.	The Government Agent, Southern Province.
The Hon. the Controller of Revenue.	The Government Agent, North-Western Province.
The Government Agent, Western Province.	The Government Agent, Northern Province.
The Government Agent, Central Province.	The Director of Irrigation.

Two Unofficial Members of the Legislative Council nominated by His Excellency the Governor.

The Hon. the Member for the European Rural Electorate.	The Hon. Sir H. M. Fernando.
--	------------------------------

Other Members appointed by His Excellency the Governor.

Amarasekera, Mudaliyar W. A.	The Divisional Agricultural Officer, Central.
Balean, O.	The Divisional Agricultural Officer, Southern.
Bamber, M. Kelway, Government Agricultural Chemist.	The Divisional Agricultural Officer, Northern.
Bandaranaike, Sir S. D. (on leave), Felix R. Dias (acting).	The Divisional Agricultural Officer, North-Western.
Beven, A. W.	The Economic Botanist.
Bibile, C. W., Ratnayakarayana.	The Entomologist.
Blair, G. W., Hunter.	Edirisinghe, Mudaliyar E. F.
The Botanist and Mycologist.	Franklin, A. A. (on leave), R. P. Gorton (acting).
Byrde, E. Maberty.	Garrison, H. D.
Cameron, D. S.	Gavin, H. W.
Campbell, N. G.	Government Veterinary Surgeon.
Chairman, Ceylon Planteurs' Association.	Gunatilake, Mudaliyar G. A.
Coles, J. B.	Hordall, John.
Coombe, Allen.	Keith, E. W.
Coombe, R. G. (on leave), J. A. Coombe (acting).	Louise Price, A. S.
Daniel, H. P.	The Manager, Experiment Station, Peradeniya.
Dassanayake, Gata Mudaliyar L. A.	Markandian, Mudaliyar K. V.
De Mel, Hon. Mr. H. L., C.B.E.	Matthew, W. R. (C. C. Durant acting).
De Mel, T. A.	Meedeniya, Hon. Mr. J. H.
De Silva, W. A. (on leave), K. Balasham (acting).	Moonesamale, Hon. Mr. T. B. L.
Dias, C. E. A.	
Driebergen, C.	

(For continuation see page 3 of cover.)

DEPARTMENT OF AGRICULTURE, CEYLON.

BULLETIN No. 69.

NOTES ON THE HABITS AND LIFE-HISTORY
OF THE INDIAN GLOW-WORM.

An Enemy of the African or Kalutara Snail.

INTRODUCTION.

CHE Indian glow-worm (*Lamprophorus tenebrosus*) first came under the special observation of the senior writer in 1920 in connection with the African snail (*Achatina fulica*), which is a pest of young plants in vegetable and flower gardens in some districts of Ceylon. In an article which appeared in the "Tropical Agriculturist" for October, 1920 (Vol. LV., No. 4), this glow-worm was mentioned as being one of the natural enemies of the snail, and the feeding habits of this predaceous insect were briefly described. At that time it was only possible to make a few observations on the feeding habits of the larvæ, and no attempt was made to carry out any detailed experiments on the habits and life-history of *Lamprophorus*. The hope was expressed that further observations might be made at a later date.

In November, 1921, Mr. John Still of Kandy found some eggs and young larvæ of a large glow-worm in his garden and kindly handed these over to Mr. F. P. Jepson, Assistant Entomologist, with a note on his discovery. Mr. Still had dug up a large clump of lilies to make separate plants of it, and while breaking it up he noticed what he took to be a female firefly and picked it up. He continues: "It was white in colour, at least 2 inches long, very flat and empty, and quite limp. But it moved, and was alive. Beneath the tail I could see in bright daylight the two patches of luminosity shine palely. Unfortunately I threw the insect away into some long grass and weeds. Then I noticed a number of larvæ, perhaps twenty or so. They were of two colours, viz., white and very dark. The dark ones were very active, and began to run away in all directions. I also noticed a number of spherical eggs, some in a little heap among the larvæ, exactly in the spot where I had picked up the large insect

I had thrown away. Other eggs were scattered about, apparently by my breaking the clot of roots. Many of the scattered eggs were damaged, the rest mostly undamaged. I collected the undamaged eggs, about two-thirds of the total number, and I caught about one-third of the larvæ. All these, together with some of the earth, were put in a box and handed to you next day. I think the earth surrounding the eggs and larvæ showed signs of containing shredded roots or grass or other fibrous material, as though some kind of nest had been burst open. You might verify this by close examination of the earth in the box I gave you, for it was taken from where the eggs lay."

The "firefly" found with her eggs and larvæ was undoubtedly a female of *Lamprophorus tenebrosus* which had evidently laid all her eggs and was reduced to the condition of a spent female exactly described by Mr. Still as being "very flat and empty and quite limp." In our breeding experiments it has been observed that the females of *Lamprophorus* show a tendency to lay their eggs at the bottom of a cavity hollowed out of the soil, and that they brood over their eggs during the incubation period. Even after the eggs have all hatched, the female may live on in the condition described above until she dies of exhaustion. The larvæ of two colours, white and very dark, were doubtless both from the same batch of eggs, the white larvæ being those which had just hatched and had not assumed the darker colour of the larvæ which had hatched a day or two, or even a few hours, earlier.

Before giving details of the habits and life-history of *Lamprophorus*, it may be of interest to outline its position in the insect world. *Lamprophorus* belongs to the family *Lampyridæ* in a group of beetles sometimes known as the *Malacodermata* ("soft-skinned"), which are characterized by the integument being softer than is the case with most beetles in which the body covering is hard and armoured. The family *Lampyridæ* includes many members which are luminous when alive, and which are commonly known as "glow-worms" and "fireflies," the emission of the light being under the control of the insects. Some of these *Lampyridæ* belonging to the genera *Diaphanes* and *Luciola* are the smaller fireflies which swarm in their myriads at night among trees during the wet seasons, giving out intermittent flashes of light, and in these groups both the male and female adults are winged beetles. In the case of *Lamprophorus* the female (see Fig. 1) is a wingless "glow-worm" and is larviform, while the male (Fig. 2) is a winged insect or "firefly," and both sexes emit a bright greenish light when

stimulated. This light comes on quickly as soon as the insects are disturbed or excited and a steady glow continues until the stimulus ceases, when the light fades away gradually.

The present article is based mainly on observations made by the writers at Peradeniya from November, 1921, to July, 1923, beginning with the specimens sent by Mr. Still from Kandy, and continuing with material collected from time to time at Peradeniya. The Kandy specimens, numbering 23 freshly-hatched larvæ, arrived at a time when it was impossible to do more than keep them alive with periodical supplies of snails, and no attempt could be made to give them daily attention, so that no records of individual moults could be kept at first. Towards the end of December, 1921, a *Lamprophorus* female was found at Peradeniya. This specimen eventually laid 80 eggs. These eggs began hatching about the middle of February, and, since the assistance of the junior writer was then available, it was decided to start a series of individual life-history records with 20 of these larvæ from female A. Six of these larvæ eventually developed into adults (see Table of Life-history, Series A 1 to A 16). The Kandy larvæ, by that time reduced to 11 by disease and other casualties, were also separated into individual cages, and more detailed records of their subsequent development were kept. Only five of these larvæ came through to the adult stage (see Table of Life-history, Series 1 to 6). With the additional assistance of Mr. F. D. Peries, Student Assistant, from the beginning of October, 1922, until about the middle of May, 1923, it was possible for us to carry on the original series in more detail, and to start further life-history series with almost daily observations. We are also indebted to Mr. E. de Alwis, Laboratory Assistant, for helping in the life-history experiments on various occasions. These records are being continued, and the results will be published later, with full descriptions of the different stages. It has been thought desirable at the present time to publish the data so far obtained, together with brief notes on the development of the various stages and on the habits of the larvæ and adults. The short descriptions of the stages included in these notes are intended merely as explanations of the figures.

NOTES ON THE DIFFERENT STAGES.

Adult Female.

Description.—The length of the adult female is 60 to 65 mm. (about 2½ inches). The freshly emerged female is a large pale yellow larviform insect, somewhat similar in size and shape to the pupa shown in Fig. 9. Head protrusible, but usually

concealed under the pronotum or first dorsal plate, flattened, brownish, and furnished with a pair of curved, acutely pointed jaws. Antennæ six-jointed. Segments of the body (thorax, and abdomen) covered with strongly arched, shining plates, partly overlapping each other. Three pairs of short brownish legs, each with a terminal pair of claws. Ventral surface of each of the second to sixth abdominal segments has four longitudinal ridges, each ridge being covered with a group of short spiny hairs directed backwards. These hairs probably assist in locomotion, but appear to break off easily. Ventral surface of eighth abdominal segment has a whitish area on each side, which becomes luminous when the female is disturbed or excited. Ninth or terminal segment of abdomen furnished with a protrusible and retractile organ composed of clusters of thread-like processes. This organ assists in loco-motion, and is used as a cleaning apparatus.

Duration of Life.—Our life-history experiments indicate that a normal healthy female may live for between three and four months, but this period may be considerably shortened. It seems probable that under natural conditions most of this period is spent in an underground chamber. The life of a female *Lamprophorus* in captivity may be divided into three distinct periods, viz. :—

- (1) The pre-oviposition period, during which mating occurs. This is a short period, lasting from about 1 to 2 weeks.
- (2) The oviposition period, lasting from about 1 to 3 weeks, during which time the eggs are being laid. (See "Habits of Oviposition.")
- (3) The post-oviposition period, which may last from about 4 to 13 weeks. Throughout this period the female remains curled up over her eggs, keeping unceasing guard over them until they hatch in about 7 weeks. Sometimes the female dies before the eggs are hatched, but she may continue to exist for several days after eggs have all hatched.

Feeding Habits.—None of the females kept in captivity have ever been observed to feed on snails, and it seems probable that they do but little feeding in the adult stage. The females kept in captivity were usually supplied with small pieces of blotting paper or cotton soaked in sweetened water, and they have been observed with their mouth parts closely applied to the paper or cotton, apparently absorbing some of the liquid. They were sometimes given water in a watch-glass, and occasionally a female was seen with its mouth parts touching the edge of the water, apparently drinking.

Habits of Oviposition.—As stated above, the oviposition period lasts, under laboratory conditions, for a period varying from about 1 to about 3 weeks. During this time the eggs are laid singly at normal rates varying from 2 or 3 to about 10 for every period of 24 hours, but sometimes a female may lay between 20 and 30 eggs during a 24-hour period. In our breeding experiments 12 females have laid respectively the following number of eggs:—86, 37, 80, 92, 63, 101, 45, 32, 85, 30, 79, 66. The percentage of hatching is high, being between 96 per cent. and 100 per cent. in the case of normal, healthy, fertilized eggs. Females which have not had a chance of mating will still lay eggs, but none of the eggs hatch, merely turning black and drying up. The eggs appear to be laid mostly at night, but are also laid during the day, especially when the female is kept in a darkened cage.

Before depositing her first eggs, the female may excavate a fairly deep hole in the earth, usually in a corner of the cage, and retreats to the bottom of this cavity. Under natural conditions the female may possibly lay her eggs in the old chamber which she occupied in her larval and pupal stages, that is to say, the full-grown larva may excavate a chamber within which it pupates, and the female may use the pupal chamber as an egg "nest." Or she may possibly construct a separate oviposition chamber.

We have never been able to catch the female in the act of moving the earth, since excavation is always done in the dark, and as soon as light is admitted to the cage she stops and buries her head in the corner. If kept in a cage with glass sides, and therefore exposed to daylight, the female simply remains quiet in a corner, avoiding the light.

Sometimes a female may lay her eggs in a low heap on the top of the soil without making a cavity. If removed from her eggs she soon finds her way back and curls up over them again. If the eggs are scattered she usually collects them one by one into a heap again, carrying each egg between the first pair of legs, or simply rolling it over the surface of the soil.

Adult Male.

Description.—The length of the adult male is from about 20 mm. to about 30 mm. A winged beetle or "firefly" (see Fig. 2). Head black, protrusible, usually concealed under the arched, blackish pronotum. Eyes large, black, rounded, occupying most of the head. Antennæ short, ten-jointed, situated between the eyes, nearly contiguous at their bases. Jaws slender, curved, and acutely pointed, overlapping considerably. Elytra, or wing-covers, brownish, soft, shorter

than the abdomen, and not fitting closely over it. Abdomen blackish above and pale brown beneath, with seven visible segments. Luminosity proceeds from two small whitish areas, one on each side of the seventh ventral segment.

Duration of Life.—The male *Lamprophorus* usually lives for a comparatively short time in captivity as compared with the female. The normal duration of the male life is from 10 to 27 days, but one male survived for 78 days. (See Table of Life-history, A 11.)

Feeding Habits.—None of the males have been observed to feed on snails. In the life-history experiments the males were fed in the same way as the females, and occasionally they may tear the saturated paper into fine shreds with their sharply-pointed jaws. It seems probable that under natural conditions they may frequent flowering plants.

Mating Habits of Male and Female.

The following note on the mating habits of *Lamprophorus tenebrosus* is recorded by Gravely* :—"The female may sometimes be found at dusk in vegetation by the roadside at Peradeniya, sitting curled up on the ground with the tail erected so as to expose her light to the best advantage. Males fly up with a loud buzzing sound, but without lights, and drop close to her. When copulation takes place the female uncurls, and her lights die down till they give only a faint ventral glow. If the pair be separated the female lights up again at once." The writers have not been able to observe the mating habits of *Lamprophorus* in its natural surroundings, but mating habits similar to those described above have been noticed in the breeding cages.

Eggs.

About 3 mm. ($\frac{1}{8}$ inch) in diameter when freshly laid (Fig. 4), but gradually increase in size to nearly 5 mm. ($\frac{1}{6}$ inch) before hatching (Fig. 5).

Description.—Pale yellow to pale brownish when newly laid, almost spherical; chorion or egg-shell, dull and smooth, with no colour markings or sculpturing.

Incubation Period.—This has been observed to vary from 49 days to 79 days, but the normal period, calculated from observations on 200 eggs from various females, is about 54 days.

* F. H. Gravely "Notes on the Habits of Indian Insects, Myriapods and Arachnids." Records of the Indian Museum, Vol. XI., Part VI., No. 2, pages 483-539. (December, 1915.)

Luminosity.—The eggs are slightly luminous when seen in the dark, and a very faint luminosity may be observed throughout the whole incubation period. The two luminous patches of the developing larva may be sometimes observed to glow faintly through the egg-shell when any noise is made, or when the eggs are disturbed in any way. This luminosity only becomes noticeable when the larval embryo is nearly fully developed, and is emitted entirely by the larva. It is quite distinct from the faint luminous glow given off by the egg-shells.

Larvæ.

*Description of Full-grown Larva.**—Length 65 to 80 mm., greatest width about 20 to 21 mm., shining black, lateral margins of thoracic, and abdominal dorsal plates yellowish to brownish (shown whitish in Fig. 7). Head protrusible, shining black, flattened above, usually concealed under pronotum; mandibles or jaws dark reddish brown to blackish, rather slender, curved, acutely pointed, overlapping slightly (see Fig. 8). (Mr. Paiva says: "mandibles very robust, curved, rather bluntly pointed, not overlapping each other," and figures a larva with mandibles of this description, but in no instance have we observed bluntly pointed mandibles in a larva at any stage of its development.) Antennæ three-jointed, first and second joints long and whitish, third joint very short and brownish (see Fig. 8). Eyes very small, situated almost immediately behind the bases of the antennæ. Legs black, each terminating in a single curved claw. Abdomen with underside black, membrane connecting sternal segments milky white. The ventral surface of each of the second to ninth abdominal segments bears four longitudinal ridges, each ridge being furnished with a cluster of short, stiff, recumbent hairs or bristles which curve backwards; they may sometimes be broken off in places. A cluster of soft, milky white, thread-like processes, which can be protruded at will, is situated at the end of the abdomen and is used as a "cleaning apparatus." Mr. Paiva gives the following interesting account of the manner in which this apparatus is used:—

"It (the larva) had been busy with its toilet. Having completed washing its mouth-parts in the water it now laid down to clean its body. It extended the filamentous appendage

* Shortened and adapted from the long description given by Mr. C. A. Paiva in his "Notes on the Indian Glow-worm (*Lamprophorus tenebrosus*)."*Records of the Indian Museum*, Vol. XVI, Part 1. (January, 1919.)

at the posterior end of its body, consisting of a number of soft, slender, retractile, sticky-looking objects which form a sort of brush when extended ; this was pressed closely first against each ventral segment, being drawn in its expanded state across the segment. After each segment had been cleaned this organ was retracted only to be placed on the next and succeeding segments, until all, but the one bearing the organ, were cleaned. This process of cleaning was applied to every part of the body in turn, always beginning from the anterior part. First the centre of the ventral segments was cleaned, then the right and left lateral areas. Having cleaned the underside it moved off to another spot, where it remained in a standing position and cleaned the dorsal segments. The only segment it could not clean was the apical one of the abdomen as it could not be reached."

Life-history.—The young larva emerges through a split in the egg-shell, and at first is whitish in colour, but becomes quite black within 2 or 3 hours after hatching. The young larvæ, after attaining their normal colour, are very active, and crawl about rapidly with head extended in search of food (see "Feeding Habits"). Under laboratory conditions, unless the soil in the cages is kept fairly damp the larvæ soon dry up and die. Our breeding experiments indicate that there is a considerable variation in the developmental period, as among individual larvæ of the same sex, and that after the first two moults the two sexes differ in their subsequent development, not only as regards the number and duration of instars, or periods between moults, but in respect of their relative size. During the first two instars there is no apparent difference in the size and general appearance of the larvæ, whether potential males or females. The first instar occupies about 20 days (average for 50 individuals), and the second instar is completed in about 24 days (average for 44 individuals). Careful measurements have been taken of a number of larvæ at various stages in their development, by measuring the length of the larva from the anterior edge of the pronotum or first dorsal plate to the posterior edge of the last abdominal segment. These measurements, therefore, do not include the head and terminal sucker, which are both protrusible and retractile. Measurements of the pronotum (first dorsal plate or D P₁ in notes below) across its greatest width have also been kept.

During the third instar it usually becomes possible to distinguish between what we may call male and female larvæ, since the latter show a marked increase in size over the former in this instar.

The following summary of the data of the larval development obtained so far from our breeding experiments may be of interest :—

All Larvæ :—

First Instar normally occupies from 15 to 24 days, but one larva took about 51 days. Average period for 50 larvæ is 20½ days. Length, on hatching, ranges from 15 to 16·5 mm., width of first dorsal plate (D P₁) from 5·5 to 6 mm.

Second Instar normally from 19 to 28 days, but some larvæ have taken a longer or shorter time. Average for 44 larvæ is 24 days. Length from 22 to 27 mm. D P₁ from 7 to 7·5 mm.

Potential Male Larvæ :—

There is no further great increase in size during subsequent development.

Third Instar.—A male larva may have a comparatively short third instar ranging from about 30 to 50 days, in which case it usually passes into the fourth instar. An exception to this was the male in cage No. 5, which pupated after a comparatively short third instar (see Life-history Table). Or the third instar may last for between 150 and 200 days, at the end of which period the larva changes into the pupal stage. That is to say, some larvæ only pass through three instars before pupating. Length at second moult from 35 to 40 mm. D P₁ from 9 to 10·5 mm. The larvæ with the long third instar may actually decrease in size owing to long periods without feeding.

Fourth Instar.—This may last from about 100 to about 150 days. The larva shows but little increase in size, and may eventually attain a length of 43 mm. and a width of 11 mm. across D P₁. So far no "male larva" has had more than four instars before pupating.

Potential Female Larvæ :—

These show a marked increase in size during later stages.

Third Instar occupies from about 17 to 50 days. Average for 14 larvæ is about 31 days. At the second moult these larvæ are usually about the same size as the "male larvæ," but during this instar they grow rapidly, and may be over 50 mm. in length.

Fourth Instar may occupy from about 30 to about 70 days. Length, at third moult, from 48 to 57 mm. D P₁ from 13 to 15 mm. The larvæ continue to grow rapidly during this instar, and may attain a length of about 65-70 mm. before the fourth moult.

Fifth Instar may only last about 30 days, in which case the larva usually passes into a sixth instar, or it may occupy between 100 and 150 days, after which period the larva pupates. Unfortunately some of our larvæ with long fifth instars have died before pupating. Length, at fourth moult, from 62 to 75 mm. D P₁ from 16·5 to 17·5 mm. The larger larvas increase in size only slightly.

Sixth Instar may last from 70 to about 160 days, but from 70 to 100 is probably a more normal period. A full-grown larva may attain a length of 80 mm. and D P₁ may be 17·5 mm. across. The greatest width (across third dorsal segment) may be about 20 to 21 mm. (See full-grown "female larva" in Fig. 7.)

Pupa.

Male Pupa.—Pale yellowish, somewhat resembling the future beetle in size and shape, except that the head and pronotum are curved under and the wings and wing-covers are closely applied to the sides of the body (see Fig. 11). The whole body is enclosed in a thin membranous skin. The duration of the pupal period of the males which we have had under observation so far varies from 16 to 23 days. Under natural conditions the larva probably pupates in a subterranean chamber or "dug-out," from which the beetle finds its way to the surface. In our breeding cages the larva may pupate on the surface of the soil, and the beetle may sometimes find some difficulty in freeing itself from its pupal skin. The pupa always glows faintly when disturbed, but otherwise no light is emitted.

Female Pupa.—Pale yellowish, closely resembling the adult female in colour, size and shape, except that the body is usually kept in a curved position and the pupa lies on its side. The body is covered with a thin membranous skin, as in the case of the male. A faint luminosity can be observed if the pupa is disturbed. The pupal stage only lasts from 7 to 10 days, so far as we have observed, and at the end of this time the female emerges into the adult stage.

Stage	Number	Incubation period	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Sixth instar	Total larval period	Sex	Pupa period	Period from egg to adult	Adult period	B1	B2
Egg	54*	6.4	5.4	5.4	5.4	5.4	5.4	5.4	5.4	♂	—	—	—	54	79
Incubation period	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
First instar	2	2	2	2	2	2	2	2	2	♂	—	—	—	22	23
Second instar	2	2	2	2	2	2	2	2	2	♂	—	—	—	20	23
Third instar	2	2	2	2	2	2	2	2	2	♂	—	—	—	26	25
Fourth instar	2	2	2	2	2	2	2	2	2	♂	—	—	—	57	33
Fifth instar	2	2	2	2	2	2	2	2	2	♂	—	—	—	191	187
Sixth instar	2	2	2	2	2	2	2	2	2	♂	—	—	—	124	33
Total larval period	271	24.5	34.2	11.4	23.2	2.53	17.2	21.0	24.9	♂	—	—	—	162	85
Sex	♂	♂	♂	♂	♂	♂	♂	♂	♂	♂	—	—	—	—	—
Pupa period	9	9	7	16	10	23	23	10	20	—	—	8	21	20	19
Period from egg to adult	—	—	—	—	—	—	—	—	—	—	—	—	—	306	—
Adult period	—	—	—	—	—	—	—	—	—	—	—	—	—	26	—
Pre-oviposition period	11	8	7	—	—	—	—	—	—	—	—	—	—	—	4
Oviposition period	13	8	11	—	—	—	—	—	—	—	—	—	—	—	—
Post-oviposition period	73	96	46	46	46	46	46	46	46	—	—	—	—	—	85
Total adult period	97	112	64	1	74	0	—	—	—	—	—	—	—	—	—
Total length of life cycle	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
From laying of egg to death of adult	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
Total	431*	420†	467†	196†	370†	330†	261†	319	407	—	—	—	—	353	109
											—	—	—	370	437
											—	—	—	356	364
											—	—	—	353	437

Explanation of Table.

* Nos. 1 to 6 are the survivors of the larvae sent by Mr. Still. These had just recently hatched, but the incubation period was, of course, unknown. It is here given as 54 days since this appears to be about the normal period of incubation.

⁴ Approximate. In the case of the male A13 was accidentally killed during its pupal period

The above table gives the records of those specimens and the records of her life which have been published up to the time of going to press.

FEEDING HABITS OF THE LARVÆ.

It seems probable that the larvæ of *Lamprophorus* in their natural haunts may have to hunt around for some time before they find a snail which they can tackle conveniently. We have sometimes observed several young larvæ feeding all together on a fairly large snail, and it seems probable that if a larva is sufficiently hungry it will go for any snail that it happens to meet, except perhaps the very large snails, which are usually too tough for even a large larva to manage.

As soon as a larva finds a suitable snail, it seizes some portion of the snail's body with its sharply-pointed jaws. The snail immediately withdraws into its shell, at the same time giving off a quantity of frothy liquid and mucus. The larva gradually sucks up the liquid, and usually follows the snail into its shell. The snail sometimes makes persistent efforts to come out again, but the larva keeps on irritating it, and eventually the snail retires as far as possible into its shell followed by the larva, which usually remains for several hours with its head and part of its body inside the shell until it has completed its meal. The *Lamprophorus* larvæ seem to feed mainly on the liquid secreted by the snails and on the semi-liquid contents of the intestine. Their curved, sharply-pointed jaws are more adapted for lacerating the flesh of their prey than for actually chewing and devouring pieces of flesh.

Mr. Paiva in his Notes on *Lamprophorus tenebrosus* already referred to describes the jaws of a full-grown larva as being "very robust, curved, rather bluntly-pointed." He had two large *Lamprophorus* larvæ under observation for several weeks, and he mentions one of these larvæ as inserting its head into the shell, seizing the snail, and gradually devouring it. He continues: "Occasionally it (the larva) threw out some portion of the snail's body, and in one instance I saw it come back to the spot where it had thrown out some refuse, as it were, and eat up what it had a moment ago apparently rejected." This method of feeding would be quite in keeping with the possession of bluntly-pointed jaws. So far we have not observed any full-grown larva of *Lamprophorus tenebrosus* with jaws of this description; either in the case of larvæ picked up outside or in the case of those bred in captivity. Occasionally a larva may have its jaws worn down slightly at the tips, or sometimes the end of one of the jaws may have broken off.

Number of Snails Eaten.—Careful records have been kept of all snails eaten by the larvæ of the later series during their whole period of development, but most of the data is incomplete at present. There are indications, however, that "male

larvæ" can account for about 20 to 40 snails, while "female larvæ" feed on from 40 to 60 snails during their period of development. All the larvæ in captivity are kept supplied regularly with fresh snails of suitable size whenever required. The male larvæ can go for long periods, sometimes from 3 to 4 months, without touching a snail, even though fresh snails are frequently supplied to them. It is essential, however, that the earth in their cages be kept damp. The female larvæ feed more regularly throughout their development, and rarely go for more than a month without feeding on a snail. It seems probable that during long periods of drought, when all the snails have buried themselves and closed up the mouth of their shell with a parchment-like covering, the larvæ must find it very difficult to obtain their usual food, and they may themselves also retire to aestivate underground for long periods with little or no feeding.

SEASONAL HISTORY.

No definite records have been kept of the seasonal history of *Lamprophorus*, but from our general observations it may be said that the females are usually to be seen from about October to about January, and the young larvæ appear to be most numerous during the early months of the year. About the middle of February this year it was noticed that a deep concrete drain near the Entomological Laboratory at Peradeniya appeared to serve as a trap for *Lamprophorus* larvæ. They apparently fall into it at nights and are unable to get out again, and unless they are rescued they are cooked by the heat of the sun by mid-day. Collections of larvæ were made almost daily from about the middle of February to about the middle of April, and for the first month or so the collections averaged about 50 living larvæ per collection. The majority of the larvæ were in the first and second instars. By the middle of April the daily number found in this particular spot had fallen to below 20 per diem, and by early in June, when the rains came, it was difficult to find as many as 10 a day. Since then no regular collections from the drain have been made, as most of the trapped larvæ doubtless get washed away by heavy rains. It is impossible to say at the present time at what season of the year the young larvæ are most numerous around Peradeniya, but at any rate the above figures indicate that this year the young larvæ of *Lamprophorus* hatched in fairly large numbers from January to March. It is hoped that it will be possible to make regular observations in future on the seasonal prevalence of *Lamprophorus*.

So far as we can tell at present, the females of *Lamprophorus* emerge and lay their eggs towards the end of the year. These eggs hatch during the early months of the year after about 8 weeks, and it is probable that most of the larvae are full grown within 8 or 9 months. The pupal period is quite short, only about a week in the case of the females, and from 2 to 3 weeks in the case of males. So that the complete period of development from egg to adult would be about 11 months for females; and about the same time or shorter for males.

THE STATUS OF "LAMPROPHORUS TENEBROSUS."

The African snail has been very numerous in the Kandy District for many years, but at the present time it seems to be less prevalent. It cannot be said at the present time that the reduction in numbers has been due mainly to *Lamprophorus*, but rather to the systematic daily collection and destruction of the snails. There are indications, however, that this large glow-worm is doing an appreciable share in keeping down the snail around Peradeniya at any rate. The snail has spread to new areas within recent years, but we have no data as to whether *Lamprophorus* has spread with it. It should be a fairly simple matter to introduce *Lamprophorus* into the new haunts of the snail, but it cannot be expected that this glow-worm will have much effect in keeping the snail in check. It is suggested, however, that experiments might be tried to introduce *Lamprophorus* into snail-infested areas in which it is known to be rare.

SUMMARY.

The Indian glow-worm (*Lamprophorus tenebrosus*) belongs to that group of the Coleoptera or beetles which have a soft body covering as compared with the hard integument of most other beetles. It also comes under the family *Lampyridæ*, which contains many luminous forms. *Lamprophorus* is luminous in all stages of its development, from egg to adult, but only glows if disturbed or excited. The glow comes on rather quickly near the end of the body, and remains steady so long as the stimulus is applied, but dies away gradually. In the case of *Lamprophorus*, the female is a yellowish larval form glow-worm, while the male is a small winged beetle.

A series of breeding experiments have been carried out at Peradeniya under laboratory conditions over a period of more than one and a half years, and these experiments are being continued. Our experiments indicate that a female may lay from 30 to about 100 eggs, and that she broods over them

during the incubation period, and may live on for several days after the eggs have hatched. The incubation period is about 7 weeks. The development of males and females differs to some extent, the "male larva" only having three or four instars, while the females have five or six. The larval period for both males and females seems to occupy about 8 or 9 months, but some males may take a shorter time and some females a longer time. The pupal period for females is about 1 week to 10 days, and for males about 2 to 3 weeks. A female adult may live for between 3 and 4 months, but more normally for 2 to 3 months. The male adult may live over 2 months, but the more normal period seems to be about 2 weeks. The whole developmental period occupies under one year under normal conditions.

Lamprophorus tenebrosus is nocturnal in its habits, and the larvae and adults remain in concealment during the day. The eggs are probably laid in an underground tunnel or chamber, and when the young larvae eventually emerge, they probably scatter and construct burrows for themselves, or they may hide in sheltered places under heaps of stones, bricks, &c., or among the roots of plants.

The larvae seem to feed normally on the African snail (*Achatina fulica*), and probably other local snails. They have very sharply-pointed, curved jaws, with which they seize their prey and lacerate the flesh. The snail secretes a quantity of liquid and mucus, some of which is sucked up by the larvae until the snail gradually dries up. Certain parts of the snail, such as the contents of the intestine, appear to be eaten, but the mouth parts of the larvae are not adapted for chewing.

Neither male nor female *Lamprophorus* have been observed to feed on snails.

Lamprophorus cannot be considered a very efficient enemy of the African snail, but in localities where this glow-worm is numerous it probably does some good. Our observations indicate that in captivity a "male larva" will kill from about 20 to 40 snails during its life, while a "female larva" accounts for about 40 to 60 snails during its larval stage. The snail has spread to new areas within recent years, and it is possible that *Lamprophorus* is still absent from such areas. Experiments might be made to introduce *Lamprophorus* into such areas.

J. C. HUTSON.
G. DOUGLAS AUSTIN.

Peradeniya, July, 1923.

THE LARGE GLOW-WORM.

(*Lamproporus tenebrosus*, Wlk.)

Figure 1.—Female glow-worm, wingless, shrunk to about two-thirds of original length after egg-laying. Newly emerged female is about the size of figure.

Figure 2.—Male glow-worm, or firefly, winged.

Figure 3.—Female in natural position over her eggs.

Figure 4.—Eggs, freshly laid.

Figure 5.—Eggs, fully developed, showing increase in size.

Figure 6.—First-stage larva or glow-worm.

Figure 7.—Full-grown larva.

Figure 8.—Head of full-grown larva, $\times 4$.

Figure 9.—Female pupa, about same size as newly emerged female.

Figure 10.—Male pupa, with body extended to show full length.

Figure 11.—Male pupa, $\times 2$, side view, natural position.

Figure 12.—Larva or glow-worm feeding on a snail which has withdrawn into its shell.

All figures natural size except where otherwise indicated.

